EXERCISE WITHIN LOWER BODY NEGATIVE PRESSURE AS AN ARTIFICIAL GRAVITY COUNTERMEASURE

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INTRODUCTION

Current exercise systems for space, which attempt to maintain performance, are unable to generate cardiovascular and musculoskeletal loads similar to those on Earth [1, 2]. The purpose of our research is to evaluate the use of lower body negative pressure (LBNP) treadmill exercise to prevent deconditioning during simulated microgravity.

METHODS

Fifteen sets of identical twins (16 males and 14 females, 21-36 years) remained in 6º head-down tilt (HDT) bed rest for 30 days to simulate microgravity. One twin from each pair (EX) was randomly assigned to perform 40 min of supine treadmill exercise in an LBNP chamber at 1.0-1.2 body weight, followed by 5 min 50 mmHg static LBNP for six days per week. Their siblings served as non-exercise controls (CON).

RESULTS

Orthostatic tolerance (time to pre-syncope), plasma volume, and sprint speed decreased significantly ($p < 0.05$) after 30 days bed rest in the CON group, but was relatively maintained in the EX group. Upright VO_2pk, muscle strength, and endurance decreased significantly in CON group, but were preserved in the EX group. Also, the EX group had normal spinal compressibility to axial load and significantly higher back muscle strength after bed rest than the CON group. Urinary n-telopeptide excretion, an index of bone resorption, was increased during bed rest in CON, but not in EX subjects [3]. However, osteoblast activity was not improved in the EX group.

DISCUSSION

Our treadmill exercise protocol within LBNP maintains plasma volume, orthostatic responses, upright exercise capacity, muscle strength and endurance during bed rest. LBNP exercise counteracts the elevation of osteoclast activity associated with bed rest, but resistive exercise may be needed to increase bone formation. These results document the efficacy of our exercise countermeasure in both males and females during 30 days of HDT bed rest. Treadmill exercise in LBNP may be an early, low mass, low power and efficacious form of artificial gravity for exploration missions [4]. However, our current LBNP exercise hardware must be redesigned for space flight and crew habitability. Future studies will include a combination of supine treadmill exercise in LBNP and flywheel resistive exercise as a part of the International Long-Term Bed Rest Project.

EARTH BENEFITS

This research is also applied to improve rehabilitation of orthopaedic patients and performance of athletes.

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